Manual for the Assessment of the Health of Georges Bay: Community Monitoring

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Assessment of the health of Georges Bay

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Contents

INTRODUCTION ***4***

Background 4
Developing the monitoring program……..... 4
Important features of the Georges Bay monitoring program……5
Safety during monitoring……...…5
Indicators of estuarine condition……...6

MONITORING METHODS AND EQUIPMENT ***7***

Site information……..7
Site map……..8
Basic measures of ecosystem condition..... 9
Habitat extent……...…9
Temperature……..10
Salinity……..11
Turbidity……...12
Dissolved oxygen……13
Chlorophyll- a……...14
Community monitoring……15
Algal blooms……15
Mass mortalities……...…16
Shoreline position……....….17
Litter……18
Invasive species……19
Important indicators……...20
Nutrients in the water column……..20
pH……21
Animal or plant species abundance……..22
Toxicants: sediment, water column, biota……....23
Pathogens……24

APPENDIX A: Water quality monitoring data sheet……25

APPENDIX B: Mass mortality data record……26

Introduction

Background

This manual describes a monitoring program for assessment of the health of Georges Bay. It includes indicators of estuarine health that are recommended for monitoring the bay and details of the methods and equipment used to measure these indicators.

The manual follows on from a report on the 'Establishment of an integrated water quality monitoring framework for Georges Bay' by Crawford and White (2005). In this report the water quality information available for Georges Bay was summarised and a preliminary monitoring program was recommended. A report card for the health of Georges Bay for the twelve months July 2004 to June 2005 was also provided. More general information on the ecology of Georges Bay is available in another report 'Bringing Back the Bay: *Marine Habitats and Water Quality in Georges Bay*' by Mount et al (2005).

The indicators that are recommended for monitoring in Georges Bay are based on those recommended for monitoring estuaries and coastal waters in Tasmania by the Tasmanian Coastal, Estuarine and Marine (CEM) Indicators Working Group. This recommended set of indicators is detailed in The Tasmanian Indicator Compendium, draft form available at: http://www.environment.tas.gov.au/cm_draft_tasmanian_estuarine_coastal_marine_indicators.html. A summarised version of the Tasmanian Indicator Compendium entitled 'Indicators for the condition of estuaries and coastal waters in Tasmania' was written by Crawford (2006).

These Tasmanian indicators are a subset of the national indicator set and are those that are considered to be a high priority for monitoring in Tasmania. Information on the national indicator set is available in the Coastal CRC Users Guide: Scheltinga *et al* (2004). Users' guide to estuarine, coastal and marine indicators for regional NRM monitoring; available at http://www.coastal.crc.org.au/Publications/Indicators.html . They are also listed on the Australian Government NRM website, available at http://www.nrm.gov.au/publications/factsheets/me-indicators/index.html#ecmhi.

Developing the Monitoring Program

A number of manuals and reports have already been written on developing monitoring programs for estuarine health in Australia, which describe the requirements of monitoring programs and suitable methods and equipment in considerable detail. As a consequence, this manual is purposely short and to the point about methods recommended for assessment of the condition of Georges Bay. For further information about setting up an estuarine monitoring program in Tasmania and other indicators and methods, two reports are recommended:

1. Indicators for the condition of estuaries and coastal waters' by Crawford (2006)
2. Waterwatch Australia National Technical Manual Module 7 Estuarine Monitoring (2006).

A recommended general book for identification of estuarine and marine flora and fauna is *Australian Marine Life, the plants and animals of temperate waters* by Edgar (1997). As the author is Tasmanian, this book contains many photographs of animals and plant found in Tasmanian waters.

Important features of the Georges Bay monitoring program

- The environmental variables recommended for monitoring have been chosen to give an overall picture of the health of Georges Bay. They are not targeted at point sources of pollution.
- **It is very important that the same set of environmental variables is monitored at the same sites over time using the same monitoring methods**. If sampling is conducted at different sites or using different methods then we would not know whether any change observed is due to a change in environmental condition or because it is at another site or different methodology.
- The environmental variables recommended, which are a combination of water column and biological variables, are considered to be the minimum set for cost-effective assessment of the condition of the bay. There are a number of other variables that could be monitored but it is important that the same minimum set of variables is monitored each time to be able to detect any change in condition.
- The sites recommended for monitoring in Georges Bay have been chosen based on their representativeness of the bay and on the availability of data at that site from previous studies in the bay. Where possible sites have been chosen that have previously been monitored so that comparisons can be made between current and past results.
- Because some estuarine environmental variables vary significantly according to the tides, it is important to monitor at the same stage of the tide each time. Following on from previous monitoring in Georges Bay, monitoring water column variables during the outgoing tide and preferably as close to slack low tide as possible, is recommended.
- Some environmental variables, especially water quality measures, can change dramatically between normal conditions and during floods, therefore sampling during flood events is recommended. The impact of these flood waters on estuarine health is currently poorly understood and more data are required.

Safety during monitoring

Safe monitoring methods are of utmost importance as the estuarine and inshore water environments are renowned for their unpredictability and rapidly changing conditions. Rogue waves, rapidly changing tides, fast changes in sea condition, partially submerged floating objects and sudden changes in water depth are not uncommon in estuaries. Thus it is essential that monitoring in estuaries is never conducted alone and a constant eye is kept on the weather and surrounding conditions. Personal floatation devices must be worn when sampling from a boat or in streams.

Indicators of estuarine condition

The indicators of estuarine condition that have been recommended by the Tasmanian Coastal, Estuarine and Marine (CEM) Indicators Working Group are listed in Table 1. These include some indicators that are readily measured by community people with minimal training whereas others require considerable experience and often external funding. Because there is a wide variety of expertise and financial support amongst community groups and local councils, it is difficult to recommend a standard monitoring program. As a consequence the indicators have been divided into two groups: (i) simple and inexpensive methods suited to any community group and (ii) more complicated methods requiring some expertise and often external funding.

It must be emphasised that the monitoring methods recommended in this manual are those considered to be most appropriate at the time of writing. However, they should be regularly reviewed as more data become available and modified to incorporate new and improved methods.

Table 1. Recommended indicators of the condition of estuaries and coastal waters in Tasmania and their suitability for community or expertise-based monitoring.

Basic measures of ecosyst condition	***Community-based monitorin***	***Expertise-based monitoring***
Temperature	√	√
Salinity	√	√
Dissolved oxygen (especially bottom waters	√	√
Turbidity	√	√
Chlorophyll-a	**?**	√
Habitat extent	**?**	√
Important indicators		
Animal and plant species abundance		√
Shoreline position	√	√
Nutrients in the water column	**?**	√
Toxicants		√
Pathogens	**?**	√
pH	√	√
Community monitoring		
Algal blooms	√	√
Mass mortalities	√	
Litter	√	
Invasive species	√	√

Monitoring methods and equipment

Site information

Five sites have been selected for monitoring based on their representativeness of the bay and on the availability of data at that site from previous studies in the bay. These sites are shown in Fig. 1 and are described in Table 2 below.

It is essential that these sites are monitored each time and not changed for a 'more interesting' site nearby. This consistency of sampling the same sites each time is critical to showing any changes if they occur.

At each sampling site it is very important to document background information on each monitoring occasion, including:

- the name of the person conducting the monitoring
- the date and time of day
- state of the tide
- weather conditions
- any notable observations

An example data sheet for each site is provided in Appendix A.

Table 2. Visual references and GPS co-ordinates for Georges Bay monitoring sites

Site	Description	GPS Co-ordinates
GB1	Green navigation pylon in the centre of the channel slightly south west of Lords Point	5426947 N 609946 E
GB2	At the base of the Yellow Bluff cliffs, level with the last house on the top of the Stieglizt end of the bluff approximately 200m off shore	5424691 N 608014 E
GB3	An equal distance between the red navigation pylon and Lowrys Point	5423922 N 605346 E
GB4	Approximately 200m off Humbug Point in a westerly direction, an equal distance between the point and the northern most yellow corner marker of the nearby oyster lease	5426681 N 607836 E
GB5	In the creek on the western side of Treloggen Bridge on the Binalong Bay road	5425683 N 605902 E

Fig. 1. Map of five water sampling sites in Georges Bay (*www.thelist.tas.gov.au)*

Habitat extent

The health of estuaries and coastal waters depends on the maintenance of a diverse range of habitats. Loss of habitat results in the loss of organisms that need that habitat to survive and thus a decrease in biodiversity.

A detailed map of the subtidal habitats of Georges Bay has already been prepared by Mount et al (2005) from the Tasmanian Aquaculture and Fisheries Institute (Fig. 2). It is recommended that this map is updated every five years to examine whether any changes in habitat are occurring; for example a change in the size and area of seagrass beds or sand/silt sediments.

Community mapping of the distribution of key intertidal habitats in a localised area can be undertaken by community groups using aerial photography and groundtruthing the habitat types identified. Some aspects of habitat mapping will require expert advice, such as interpretation of satellite images or plant species identification.

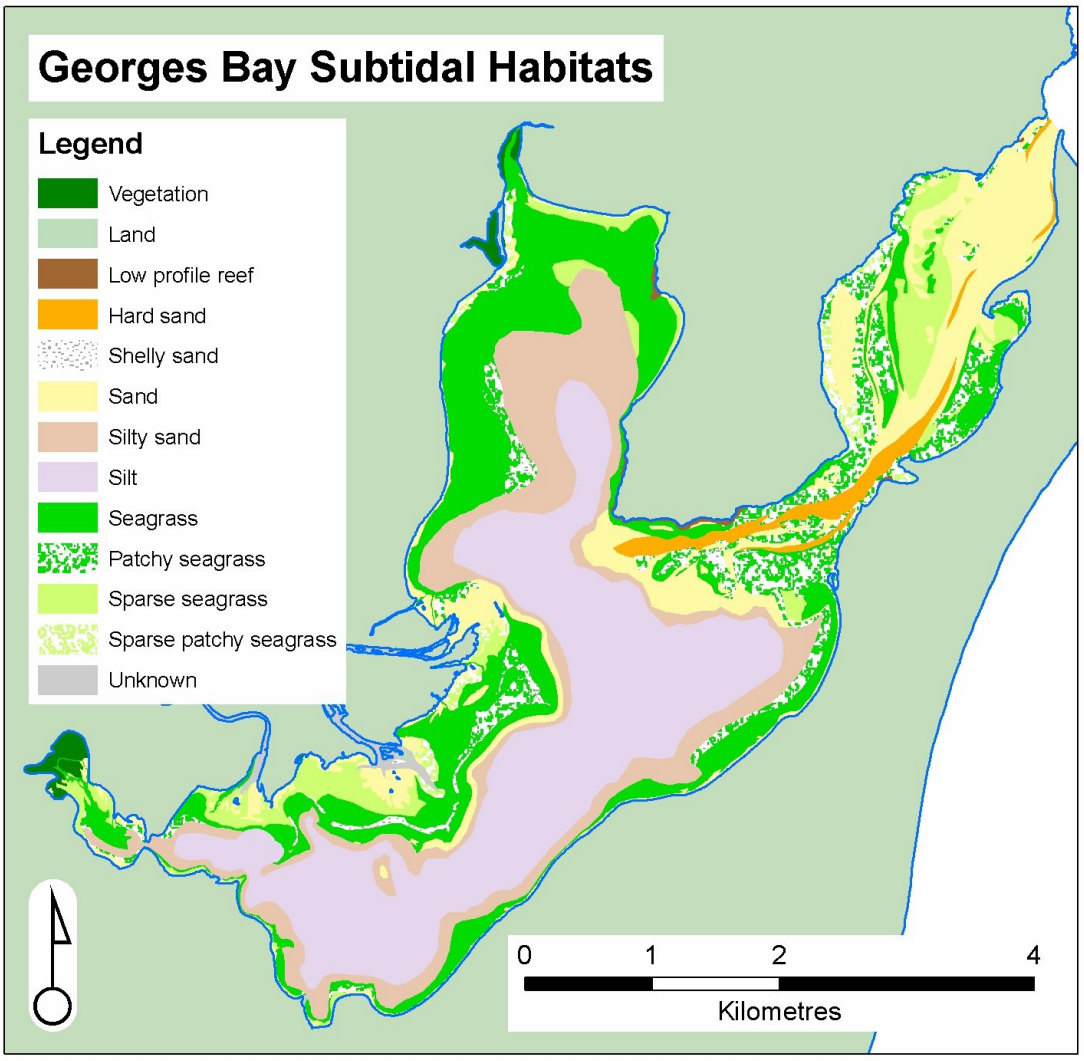

Fig. 2. Map of subtidal habitats in Georges Bay (from Mount et al (2005).

Temperature

Temperature and salinity are recommended for monitoring, largely to supply supporting information, rather than as indicators themselves of CEM condition. Both temperature and salinity affect many physical, chemical and biological characteristics and processes with an estuary or coastal waters. As they both affect dissolved oxygen concentration, temperature and salinity must be recorded in conjunction with measurements of dissolved oxygen.

Water temperature is a key factor controlling the rate of biological processes. An increase or decrease in temperature can have substantial effects on the physiology of the fauna and flora and aquatic ecosystems functioning. Temperature recorded over long periods of time (years) is an indicator for global warming.

Water temperature can be measured using a thermometer or a field meter. It is also measured by salinity and dissolved oxygen meters and instructions for using these field meters are given below.

Salinity (Electrical conductivity)

Salinity is a measure of the amount of salt in water. It is an indicator used to understand the hydrodynamics and mixing processes occurring in an estuary. Salinity is also important in the ecology of an estuary as many organisms can only survive within a limited salinity range. It is a key indicator of environmental flows into estuaries.

Seawater is measured by marine biologists as parts per thousand or PSU (Practical Salinity Units). Full seawater has a salinity of approximately 35 parts per thousand (ppt). However, most people working on freshwater systems measure salinity as electrical conductivity in microSiemens/cm. Full seawater is typically 51,500 µS/cm.

Salinity is generally measured using a field meter, although it can also be measured using a refractometer or a hydrometer which records specific gravity. The advantage of a field meter is that the salinity probe is attached by a cable to the meter and thus can be used to profile salinity values from the surface to the seabed. Because freshwater is less dense than seawater it generally flows over the top of saline waters and in this situation salinity increases from the surface towards the seabed.

How to Measure

Step 1. Ensure probe cable is connected securely to meter. Press power key to activate meter. Wait until screen displays 0.00 SAL before putting probe into the water

Step 2. Lower probe into water and wait until display stabilises before taking both the salinity and the temperature reading

Step 3. Remove probe from water and press power button again to switch off

Trouble Shooting

- Screen displays measurement in uS/cm instead of SAL – press mode button once and it will switch to SAL.
- Screen displays 0.00 SAL despite probe being in water – water may have high fresh water content therefore very low salinity.
- Meter produces improbable measurement – meter possibly needs calibrating - refer to monitoring program co-ordinator.

Turbidity

Turbidity is a measure of the amount of suspended material in the water column, or cloudiness. Increased turbidity reduces the penetration of light in water and affects the depth at which submerged aquatic vegetation can grow. High turbidity levels may indicate erosion, sediment resuspension, wastewater discharge or algal blooms. Because increased turbidity commonly occurs as a result of altered land-based activities, such as land clearing, intensive agriculture, and urban development, it is an important indicator of estuarine condition.

Turbidity is commonly measured using a portable turbidity meter or a turbidity probe and the units of measurement are NTUs (Nephelometric Turbidity Units).

Measurement Notes

- Meter should not be removed from case for use.
- Meter needs to be placed on a flat steady surface when in use.
- Do not use in direct sunlight, cover with a cloth if necessary.
- Test samples immediately after collection.

How to Measure

Step 1 Remove three sample bottles from kit, rinse with seawater from the sample site, then fill each bottle to the rim with seawater from just below the surface, avoiding any debris floating at the surface.

Step 2. Each bottle should be cleaned gently on the outside with a lint free cloth to ensure the bottle surface is free from fibres and dirt. Do not use scratched bottles and do not shake or agitate the sample as this will introduce air bubbles.

Step 3. Open compartment lid and place sample bottle into cell compartment, aligning the diamond on the sample bottle with the notch beside the cell compartment.

Step 4. Press the “power” button. Wait until the screen displays 0.00 NTU and then press “read”

Step 6. The screen will flash for several seconds, wait until the reading has stopped flashing and the small light bulb symbol in the left of the screen has disappeared before recording the measurement.

Step 7. Press “power” button to turn power off before removing sample and repeating the process.

Trouble Shooting

- Flashing battery symbol – install new batteries.
- Error messages (displayed as E followed by a number) – refer to co-ordinator.
- Numeric display flashing, sample is too turbid for selected range – refer to co-ordinator.
- CAL? (flashing or non flashing) problem with the calibration of the machine – refer to co-ordinator.

Dissolved oxygen

The concentration of dissolved oxygen (DO) is an important measure of the health of an estuary. Decreases in DO are often related to increased organic load, such as from sewage, algal blooms and influx of organic matter into an estuary. This increase in organic load can lead to increased bacterial activity, resulting in greater oxygen consumption. As a consequence, the available oxygen, especially in bottom waters, can become depleted. *It is thus important to measure dissolved oxygen in bottom waters.*

Dissolved oxygen is commonly measured using a field DO meter and probe. These probes are sensitive and need to be carefully handled and maintained. Results can be reported as either mg/L or percentage saturation. Note: dissolved oxygen concentrations decrease with increased temperature and salinity. Thus temperature and salinity need to be measured at the same time as DO.

Measurement Notes

- Ensure probe cable is connected securely to meter.
- Display needs to read 100% or close to this in air before putting the probe into the water. Always allow the reading to stabilise before placing the probe into the water.

How to Measure

Step 1. Remove protective cap from probe.

Step 2. Press power button on meter. Display will show dissolved oxygen and temperature measurements on the top line and date and time on the bottom line. Wait until the dissolved oxygen measurement, displayed as 160%S or similar, drops to around 100%S before putting the probe into the water.

Step 3. Place the probe in the water. If there is no current move the probe around slowly so that water is flowing past the probe. Wait for the DO measurement to stabilise before recording both the DO and the temperature measurements.

Step 4. Record DO at the surface and close to the sea bed.

Step 5. Remove probe from water and press power button again to switch off. Ensure protective cap is replaced on probe.

Trouble Shooting

- Meter fails to reach 100% DO when switched on (either well above or below 100) – meter requires recalibration, refer to co-ordinator.
- Flashing battery symbol – battery needs recharging.
- Meter displays “off” and then switches off – not enough power to run meter, recharge battery.
- Meter will not turn on – battery completely flat, recharge battery.
- Meter reading will not stabilise in water – ensure there is adequate water flow past measuring probe.
- Inaccurate or unstable readings – meter needs recalibration, refer to co-ordinator.

Chlorophyll-a (additional training required)

Chlorophyll-a (Chl-a) is the green photosynthetic matter found in plants and thus is a measure of the biomass of plant material, mainly microscopic algae (phytoplankton) in the water column.

Chl-a is measured by taking water samples in the field and sending them to a laboratory for analysis using a spectrophotometer, These samples are collected either in a bottle just below the surface or as a depth integrated sample using plastic tubing.

The laboratories provide a 1 L plastic bottle for the water sample. When taking the sample the bottle should first be rinsed with the water from which the sample is to be taken. The bottle should be faced into the current or flow ensuring water does not pass across the hands before it enters the bottle. After the sample is taken it should be kept cool (on ice), wrapped in aluminium foil and transported to the lab as quickly as possible.

The Waterwatch Australia National Technical Manual Module 7, Estuarine Monitoring, (2006) provides a detailed description of how to filter the water sample in the field and submit the concentrated chlorophyll-a sample on filter paper to a laboratory for analysis. Note that it is important to keep the vacuum pressure at -20 kpa; if the pressure is too high the algal cells will be broken and sucked through the filter paper. This procedure does, however, require some scientific knowledge and training. The main advantage of filtering the sample is to reduce the costs of analysis. However, Analytical Services Tasmania cannot provide a result meeting their guaranteed laboratory standards as they have not filtered the sample.

Chlorophyll a is not included in the first training program for Georges Bay because filtering the sample requires some experience and more detailed training. We are also trying to locate a cheaper version of the filtering apparatus than the standard off the shelf scientific version.

Algal blooms

Chlorophyll-a is the agreed first priority quantitative measure of algal biomass as it is widely used and the results are easily interpreted. However, because algal blooms are generally infrequent and unpredictable, information collected by on-the-spot community groups can be extremely valuable.

Algal blooms take two forms:

(i) *Microalgae (phytoplankton) in the water column*. Microalgae are too small to be individually seen by the naked eye, and these blooms are observed as regions of coloured water; for example green/brown water that can occur in estuaries or the obvious fluorescent pink blooms of *Noctiluca scintillans*.

(ii) *Macroalgae in shallow water and the intertidal zone*. Some species of macroalgae proliferate in areas of high nutrients, leading to dense algal mats These include the sea lettuce (*Ulva* sp.), the green slimy algae (*Enteromorpha* sp.) and filamentous algae attached to other plants or the seabed, such as *Chaetomorpha* sp.

How to measure:

This is primarily a visual assessment for microalgae and macroalgae..
Equipment required: camera, GPS (if available), sealable bottle, rubber gloves, esky with ice.

Record details of the algal bloom or unusual event, including:

- location of the bloom using either GPS or a map of the bay or in relation to an important feature such as Humbug Point.
- Date and time
- Weather and tidal conditions
- Sketch a map of the area of the bloom, indicating any landmarks.
- Take photos of the bloom
- Algal species (if known)
- Make notes of any unusual conditions, eg odours, mortalities of fish etc

Take a sample of the algae if identification of the species is required. Use a clean sample container, rinse it several times in the water at the bloom site and then take the algal sample. Wear protective gloves during sampling in case the alga is toxic. If the sample is macroalgae it may require seawater to be added to keep the alga alive. Store the sample on ice, away from light. Do not freeze as this can cause algal cells to burst. With the assistance of the monitoring co-ordinator get the sample to a laboratory as soon as possible for identification of the species. However many macroalgae found in Tasmania are difficult to identify.

Note: algal blooms can occur naturally and are not necessarily an indication of human impact or degradation. Some phytoplankton blooms occur with species that produce toxins, which can irritate skin or cause respiratory distress. Take appropriate precautions when handling algal bloom samples.

Mass Mortalities

This indicator is primarily for community monitoring because it relies on reports of sporadic mass mortality events that would not normally be picked up in a routine monitoring program. Such information can be extremely useful in identifying a pollutant source or cause of harm to marine and estuarine flora and fauna.

Fish or invertebrate kills (e.g. crabs) are unexpected and generally short lived events that are conspicuous by the death of a large number of animals. The frequency and magnitude of such events is an indicator of the health of an estuary. Causes include low dissolved oxygen levels, disease, toxic algae, pollutant spills or uncommon weather patterns.

How to measure:

Record as much information as possible at the site and surrounding area, and report the incident to the appropriate management authority (e.g. local council, Parks and Wildlife Service, Environment Division or Marine Resources Division of State Government). Any death, stranding or injury of threatened species, marine mammals or seabirds must also be reported to the Marine Conservation Unit of the Department of Primary Industries and Water .

- Take photographs of the dead animals and the area affected.
- Record the location and estimated size of the area affected.
- Record the date and time of assessment.
- Record the current weather conditions and for the previous 48 hours.
- Note any recent activities that have occurred in the vicinity of the mass kill.
- Count or estimate the number of dead animals of each species present and record their size. If there are large numbers of dead animals, measure off approximately five smaller areas and count the number of dead animals of each species in each area. Take the average of these counts and extrapolate to the total affected area to estimate the total number of mortalities.
- Record the presence of other animals in the area, including sick or dying animals and any with skin lesions or wounds.
- Record the presence of any unusual materials in the area, such as oils slicks, discoloured water, rubbish etc. and any activities occurring in the vicinity of the kills.
- If you have the equipment, record temperature, salinity, dissolved oxygen, pH and take water samples in clean plastic bottles for possible subsequent analysis. If appropriate take samples of sediment, oil, sludge or other foreign material and store in glass jars.
- Carefully collect samples of dying or very recently dead animals for analysis using protective rubber gloves (animal tissue breaks down very quickly after death and rapidly becomes unsuitable for analysis). Store dead fish and small invertebrates in plastic bags and keep on ice or deep freeze if the sample will not be analysed within 24 hr.
- All samples should be accurately and comprehensively labelled with the date, time, location, species, nature of sample, person who collected the sample etc.
- A mass mortality data sheet is provided in Appendix B.

Note : collect samples of dead and dying animals with extreme care so that you do not come in contact with any contaminants.

Shoreline Position

Sediments naturally move around an estuary or on the open coast as a result of water currents and wave action. However, many human activities markedly affect sedimentation and erosion rates, including land clearing, land reclamation, dredging, and construction of jetties and other artificial structures. Shoreline positions are also likely to change as a result of climate change and global warming.

The Tasmanian Shoreline Monitoring and ARChiving project (TASMARC) has been developed to provide information on shoreline movement of a selected group of Tasmanian beaches through measurement of (i) high water mark and (ii) beach profile. The methodology is explained at the website http://staff.acecrc.org.au/~johnubter/tasmarc.pdf, and has been developed for community groups.

As part of a project lead by Dr John Hunter from the University of Tasmania, shoreline monitoring will be conducted in collaboration with community groups at Georges Bay in late 2007 or early 2008.

The high tide mark measurement involves measuring the distance of the perceived high water mark from a fixed survey mark. The high water mark is defined as the most landward position of the shoreline over a period of approximately one month. Similarly the measurement of the beach profile involves measuring the height of the beach relative to the surveyors mark. Both these measurements use survey marks which need to be within a measurable distance to the shoreline and are relatively easy to access. From the LIST government website suitable survey marks for Georges Bay have been identified at the following locations:

- O'Connors Beach
- On the corner of the highway, in a small park on the right, as entering St Helens
- Kirwans Beach
- Close to the Golden Fleece Bridge
- Close to major fishing pier

These survey marks need to be assessed for their suitability for monitoring shoreline position.

Litter

Litter, whilst not an estuarine health risk *per se*, can result in animal deaths, habitat degradation and associated health risks to the general community. Toxic substances leaching from litter can also accumulate in the food chain resulting in health risks to a wide variety of marine organisms. Many species of endangered marine mammals, turtles and seabirds are at particularly risk from water borne litter.

Sources of litter range from direct dumping onshore and rubbish dumped or abandoned from commercial or recreational fishing, through to stormwater and windblown detritus.

Measurement notes

Sites selected for litter monitoring should be easily accessible, not involved in any other cleaning operation, and subject to litter accumulation.

How to Measure

Equipment list:

- GPS or topographic map
- 100 m measuring tape or trundle wheel
- Data sheets, clipboards and pencils
- Digital camera
- Appropriate clothing (heavy duty gloves and protective shoes)
- Heavy duty plastic bags
- Special container for sharps
- Scales accurate to 0.1 kg

At each site set up a transect line using the tape measure. Each transect should run from the low tide mark to the top of the beach. Record the length and GPS co-ordinates of each transect, and take photos along the transect before commencing litter collection. Collect all visible litter within 5 m either side of the transect and then sort into categories. Categories include glass, cans, plastic bottles, plastic bags, other plastics, rope, paper and cardboard, fabrics, metal, cigarette butts and miscellaneous. Count the number of items in each category. Remove sand and fouling from the waste and weigh each category. Repeat this transect twice at each site (3 transects per site).

Invasive species

Invasive plants and animals are those that do not naturally occur in an area or those that have increased in number to the extent that they are altering the natural ecosystem. Most invasive species have been introduced by human activity.

There are 58 introduced marine species that have been identified in Tasmania, 10 of which are recognised as marine pests. The Department of Primary Industry and Water (DPIW) maintains a database of invasive marine species found in Tasmania. This includes the Pacific seastar, *Asterias amurensis*, New Zealand screw shell, *Maoricoplus roseus* and the Japanese seaweed, *Undaria pinntifiata*, as well as the less obvious but regionally abundant introduced species such as the small bivalves, *Cobula gibba, Theora lubrica, Raeta pulchella* and the European/green shore crab, *Carcinus maenas.*

A port survey for invasive species has been conducted at St Helens and a number of invasive species have been identified from Georges Bay. These include:

- Northern Pacific seastar *Asterias amurensis*
- European green crab *Carcinus maenas*
- European clam *Varicorbula gibba*
- Bag mussel *Musculista senhousia*
- Japanese kelp *Undaria pinnatifida*
- New Zealand screwshell *Petrolisthes elongates*
- Toxic dinoflagellate *Gymnodinium catenatum*

Community-based monitoring of invasive species is likely to be conducted as part of monitoring other indicators and the objective is to add to the existing database of location and abundance of invasive species. Identification of and information on invasive marine species in Tasmania can be obtained from fact sheets provided by DPIW (available at the training session) and from CSIRO at http://crimp.marine,csiro.au//Marine_pest_infosheets.html

Experts at the Queen Victoria Museum in Launceston and the Tasmanian Museum and Art Gallery in Hobart can assist with the identification of invasive marine species. Any new discoveries of invasive species or extensions in distribution beyond the known range should be reported to DPIW.

Nutrients in the water column (additional training required)

Nitrogen and phosphorous are essential building blocks of animal and plant life and are cycled through the environment by biological and chemical means. In the marine environment nitrogen is often the limiting nutrient for growth, whereas in freshwater it is mainly phosphorous.

If funding is limited it is recommended that biologically available dissolved nutrients (nitrate + nitrite, phosphate and ammonium) are monitored as a priority. However, if sufficient funding is available and information is required on nutrient loads from rivers into estuaries, total nitrogen (TN) and total phosphorous (TP) should also be monitored.

Water samples for ammonium analysis are easily contaminated and great care must be taken in collecting these samples. For example, they can not be collected by a smoker because nitrogenous tar on fingers can contaminate samples. Similarly, water samples need to be collected away from the exhaust of outboard motors.

Water samples are sent to the State Government Laboratories (Analytical Services Tasmania, AST) at Sandy Bay in Hobart for nutrient analysis. The laboratories provide sample bottles, filters as required, information on how to collect and process the water samples in the field, and guidance on how long samples can be stored before analysis. Water samples for nutrients are either delivered fresh to the laboratory on the day of sampling or refrigerated at 4º C (filtered samples can be frozen), and delivered later. However, silicate samples can not be frozen.

How to measure

Dissolved nutrient tubes are 50ml red screw cap tubes accompanied by a yellow disc filter and disposable 30ml luer lock tip syringes. Begin by ensuring the tube is labelled correctly with the date, time, site, location etc. Remove a new 30ml syringe from its individual wrapper and fill syringe with water sample. Attach a yellow filter to the end of the syringe and then push the water sample through the filter into the red tube. Immediately replace the cap on the tube and store the tube on ice.

Measurement Notes

A new disposable syringe and filter must be used for each water sample taken. Fill the syringe only to capacity and discharge into tube – do not add any more water to fill the tube. Avoid touching the syringe or filter tips, or the inside of the nutrient tube cap. Smokers should not take samples as chemicals on the fingers can contaminate the samples collected. If samples cannot be transported to a laboratory immediately, they need to be frozen.

pH

pH measures acidity or alkalinity of water on a log scale from 0 (extremely acidic) to 14 (extremely alkaline). A pH of 7 is neutral and most CEM organisms prefer a pH in the range of 7-8.5. pH is generally relatively stable in estuarine and marine waters because of carbonate buffering. However, significant changes in pH may occur due to disturbance of acid sulphate soils from mine drainage or chemical pollution.

An altered pH that is higher or lower than that normally encountered by marine organisms can result in tissue damage, leading to death. Changes in pH can also affect the availability of metals and the solubility of calcium carbonate, which is important for shell-forming organisms.

pH of water is generally measured in situ using a field meter with a pH probe. These field probes are generally robust and reliable provided they are well maintained and calibrated.

Measurement Notes

- Instrument should be held upright when measuring. Only the measurement probe should be placed into the water. Do not immerse entire instrument in water.

How to Measure

Step 1. Remove black cap from end of meter.

Step 2. Press power button to switch on.

Step 3. Hold the meter in the water and observe the display. Once display has settled measurement can be recorded.

Step 4. Press power button to switch off and replace black cap.

Trouble Shooting

- Battery light is displayed – install new batteries.
- Inaccurate/instable readings – meter may need recalibration, refer to co-ordinator.
- Temperature measurement is displayed in Fahrenheit instead of Celsius – refer to co-ordinator.

Animal or Plant Species Abundance

Animal or plant species abundances are important measures of estuarine health and water quality. This is because physical and chemical measures of water quality can vary rapidly (within 24 hours) due to changing environmental conditions, such as flooding into an estuary. By contrast, animal and plant species abundance generally do not change so rapidly and are therefore a better integrator of environmental conditions over time.

In estuaries, the dominant habitat type is soft sediment and assessment of estuarine invertebrate fauna living in sand and mud sediments has been identified as a good indicator of water quality and estuarine health. These infauna do not regularly move around and are not readily dislodged (compared with fish or surface dwelling invertebrates).

Community-based monitoring of soft sediment fauna and seagrass

A simplified method of sampling invertebrate fauna in the sediments around fish farms, which is suitable for trained farm hands to use, has been developed by TAFI. This is documented in the 'Guide to the assessment of sediment condition at marine finfish farms in Tasmania' by Macleod and Forbes, (2004), available at http://www.utas.edu.au/tafi/TAFI_Download.htm#TAFI%20Technical%20Reports, TAFI Reports to Funding/Other Bodies. It is highly probable that this methodology could be adapted for community groups and this will be examined in Georges Bay at a later date.

Community-based monitoring of seagrass beds is relatively common in mainland Australia, but has not occurred in Tasmania, presumably because of the colder water, low tidal range around much of the coastline and limited distribution of extensive seagrass beds near the higher populated areas. A useful manual for community monitoring of seagrass is the Parks Victoria Technical Series No. 16, Sea Search: Community-based monitoring of Victoria's marine national parks and marine sanctuaries – Seagrass monitoring by Koss et al (2005) available at http://www.parkweb.vic.gov.au/resources/19_1326.pdf. This report describes seagrass species commonly found in Tasmania. However, the methods used to monitor seagrass condition are slightly different to those that have been employed in Tasmania.

Seagrass condition naturally changes between seasons and thus seasonal monitoring is necessary if these natural trends are to be identified. Annual monitoring in Tasmania, however, may be preferred to avoid the cold winter conditions. For annual monitoring it is important to monitor at the same time each year to avoid the seasonal changes.

Although sea grass communities are susceptible to changes in water quality and thus are widely considered to be an important indicator of environmental health, differences between species in their ecology and reproduction need to be taken into consideration when assessing abundance data.

Community monitoring of seagrass in Georges Bay is not currently planned but could be investigated if there is significant interest from community members.

Important indicators

Toxicants: sediment, water column, biota

Toxicants are chemicals that are harmful to the fauna and flora of estuaries and coastal waters. They can be natural but toxic at high concentrations or man-made substances. Toxicants can be in the sediments, in the water column or in animal/plant material.

Measurement of toxicant concentrations generally requires sophisticated equipment which is available in only a few laboratories. It is also usually expensive to measure, hence is generally only monitored when there is a specific reason to do so. A systematic approach is required where potential toxicants are identified and the monitoring program must be carefully designed in terms of where and when to monitor to ensure cost-effectiveness and sufficient data are available to verify changes.

For Georges Bay the best methods for monitoring toxicants are currently being investigated.

Pathogens

Pathogens are organisms such as bacteria, viruses, protozoans or fungi that cause disease in human and estuarine/marine organisms. Exposure to pathogens can occur in several ways, either directly through physical contact or indirectly through consumption of contaminated organisms such as shellfish. The main sources of pathogens are from warm-blooded animals, including humans, which can be concentrated in sewage and storm water overflows, and in areas receiving animal wastes, such as downstream of intensive dairy farming.

In Georges Bay the two main sources of information on pathogens has been through (i) Tasmanian Shellfish Quality Assurance Program (TSQAP), which has been monitoring thermotolerant coliforms in shellfish growing waters for many years to assess whether the shellfish are safe for human consumption, and (ii) local councils who monitor recreational beaches for primary contact, especially over the warmer months. No additional sampling for pathogens is currently planned.

If additional sampling for pathogens is required, the Waterwatch Australia National Technical Manual Module 7, Estuarine Monitoring, (2006) describes test kits for bacterial analysis which are available commercially. These include presence-absence kits and plating for counts of bacteria. The Waterwatch Tasmania – Equipment guide 2003 describes and provides prices for an easy method for identification and counting general coliform and *E. coli* colonies. It also describes the membrane filtration method which allows accurate counts of low numbers of faecal bacteria.

A new product B2P ™ on the market suitable for bacterial testing by community groups enables testing to be conducted on the spot. The water sample jars contain chemicals which specifically test for coliforms and *E. coli* and the rate of change of colour of the sample solution is related to the concentration of bacteria. This product is available from scientific suppliers and costs $25 per sample container. A similar product is available for testing coliforms and *E. coli* in foods, including shellfish; cost approx $30 per sample.

Note that the sites monitored and default trigger values for pathogens are in relation to human health risk and not environmental risk.

Appendix A: Water quality monitoring data sheet

Date: _____Time: _____

Samplers Name(s): _____

Site name:_____Tide:_____

Weather: _____

pH:_____ Turb 1:_____Turb 2:_____Turb3:_____

Depth	*Salinity*	*Temp*	*DO*	*Temp*
0				
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				

Notes:_____
_____
_____
_____
_____
_____

Appendix B: Mass mortality data record

Date _____Time _____

Water body_____

Location _____GPS Coordinates_____

Weather (temperature, rainfall, wind) _____

Collectors Name(s) and Address _____

_____

Animal Species Affected:_____

Time of death? Dying / Hours / Days? _____

Area covered by dead/dying animals:_____

Estimated no. of dead animals:_____

Size / Length of affected animals? _____

Behavioural abnormalities? (lethargic? swimming near surface?)_____

_____

External abnormalities? (Lesions / fungus / pigment discoloration/ etc.)_____

_____

Other Animals Affected: Amphibians / Decapods / Invertebrates / Mammals, Other?

_____

Water Assessment: Current flow rate and direction_____
Temperature _____ Dissolved Oxygen _____ pH _____
Salinity_____Turbidity _____
Water Colour _____ Algal blooms?_____
Floating matter, scum_____
Visible Discharges _____

Recent weather events (storms, floods, droughts_____

Adjacent land use and recent activities in vicinity of kill?_____

_____

Samples Collected: (Yes or No)

Fish _____ Water_____ Sediment _____
Algae _____Other _____

Pictures of dead or diseased fish taken? _____

Additional information: _____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____
_____

Map of fish kill area. Include sampling sites, sites photographed and direction, landmarks, direction of water flow, vegetation and north arrow.